US009238199B1

(12) United States Patent
Martin et al.

(10) Patent No.: US 9,238,199 B1
(45) Date of Patent: Jan. 19, 2016

(54) COMBINED FLOW MIXING, TEMPERING AND NOISE SUPPRESSING APPARATUS FOR A SELECTIVE CATALYTIC REDUCTION SYSTEM AND METHOD OF USE THEREOF

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 406 days.

(21) Appl. No.: **13/833,951**

(22) Filed: **Mar. 15, 2013**

(51) **Int. Cl.**
B01D 50/00 (2006.01)
B01D 53/94 (2006.01)

(52) **U.S. Cl.**
CPC ***B01D 53/9418*** (2013.01)

(58) **Field of Classification Search**
CPC B01D 53/56; B01D 53/504; B01D 53/501; F01N 3/2066; F01N 2/2892; F01N 3/2846; F01N 2330/08
USPC 422/168, 170, 172, 176; 181/240, 228, 181/204
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,149,375	A	4/1979	Wynosky et al.	
4,401,269	A	8/1983	Eiler	
5,307,628	A *	5/1994	Castagne	60/284
5,426,269	A *	6/1995	Wagner et al.	181/232
2005/0193716	A1	9/2005	Schlinker et al.	
2011/0162339	A1*	7/2011	Alexander et al.	60/39.5

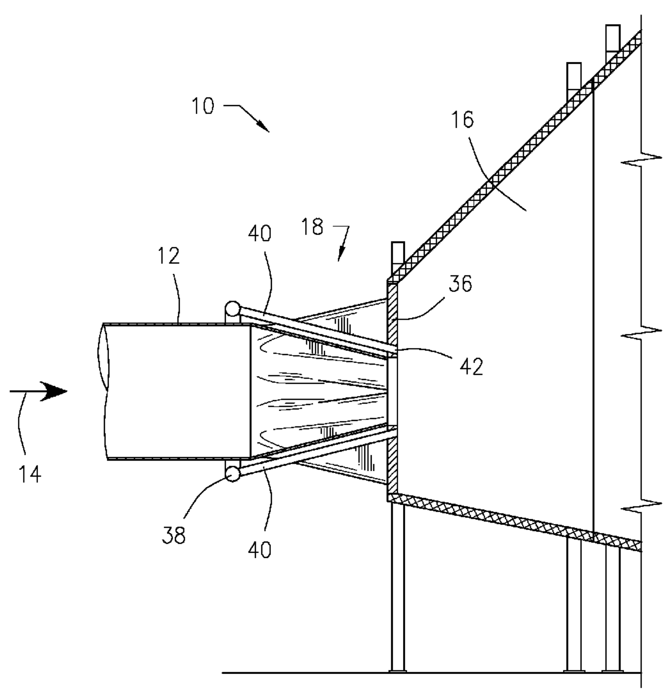
* cited by examiner

Primary Examiner — Tom P Duong

(57) **ABSTRACT**

A combined flow mixing, tempering and noise suppressing apparatus for a selective catalytic reduction system, and method of use thereof is provided. The suppressing apparatus is positioned downstream of a gas input duct of the selective catalytic reduction system in order to provide improved flow uniformity and reduced noise at the entrance to the SCR system with minimal pressure loss. The combined flow mixing, tempering and noise suppressing apparatus includes lobe depressions that extend toward a centerline axis of a gas input duct of the selective catalytic reduction system and alternating lobe protrusions leading away from the centerline axis. The combined flow mixing, tempering and noise suppressing apparatus can include a means for introducing a secondary stream, such as an air manifold or an air bustle in fluid communication with the selective catalytic reduction system.

43 Claims, 15 Drawing Sheets



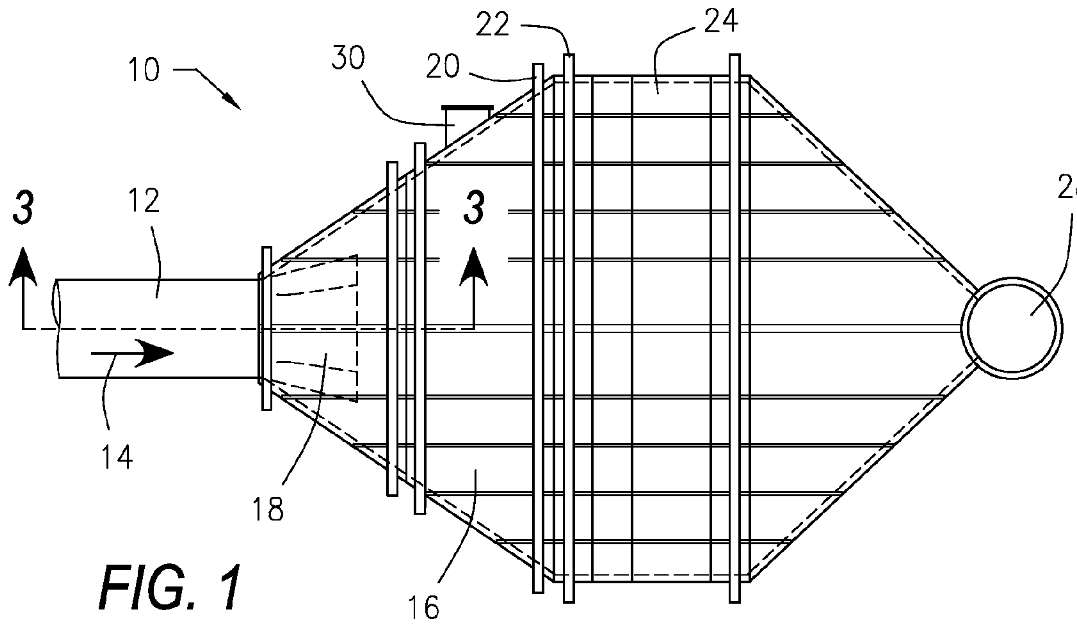


FIG. 1

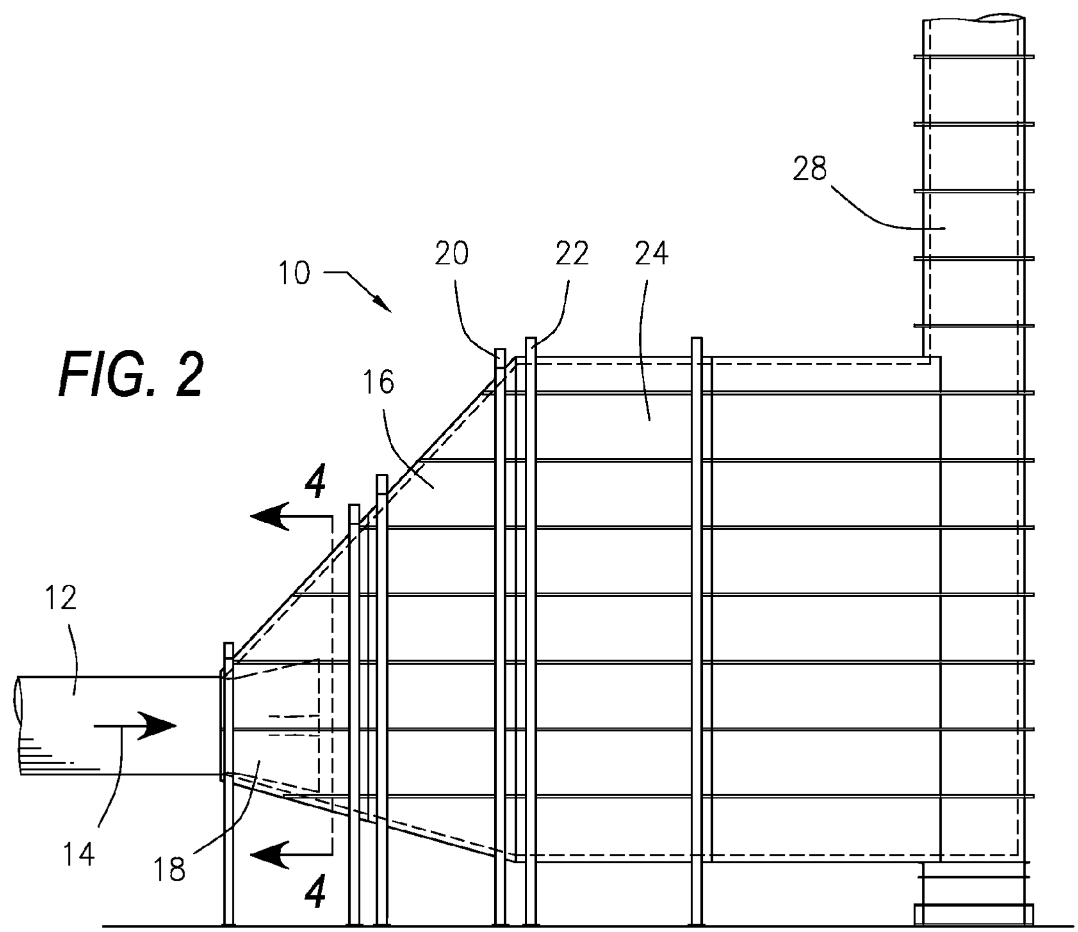


FIG. 2

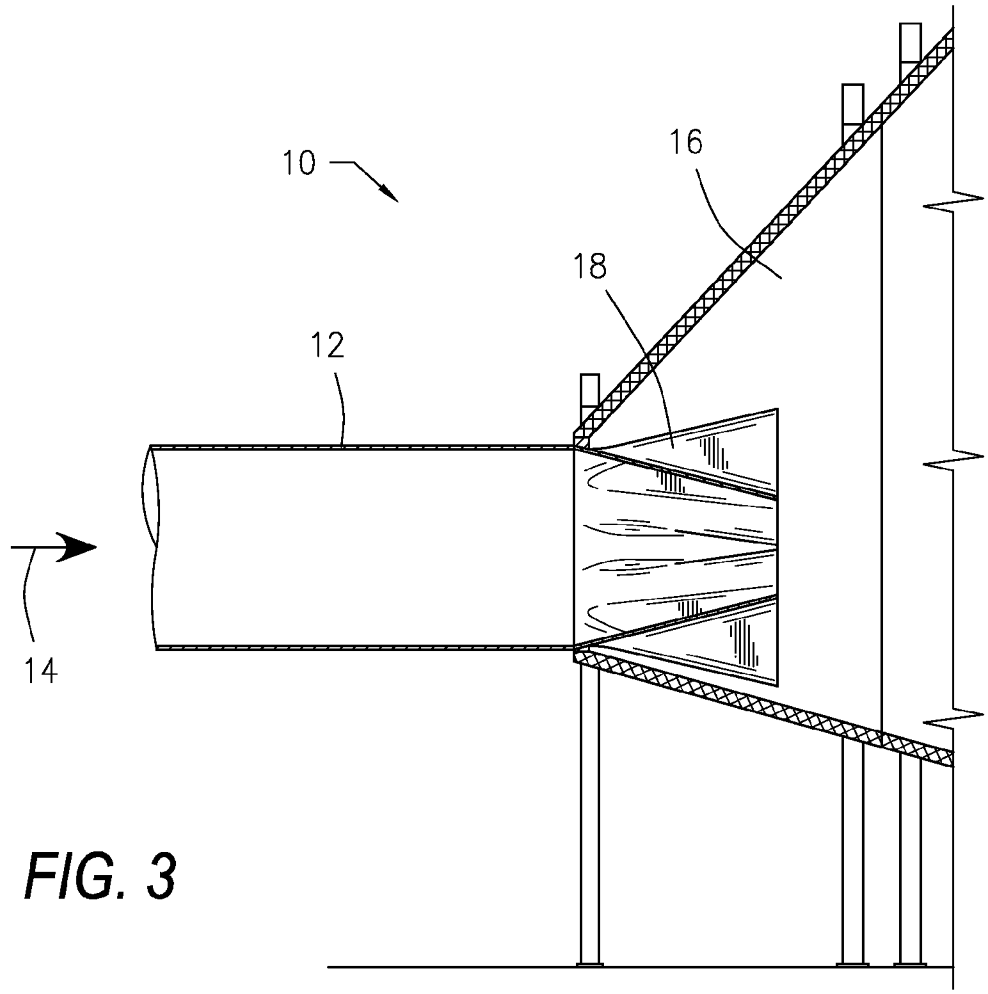


FIG. 3

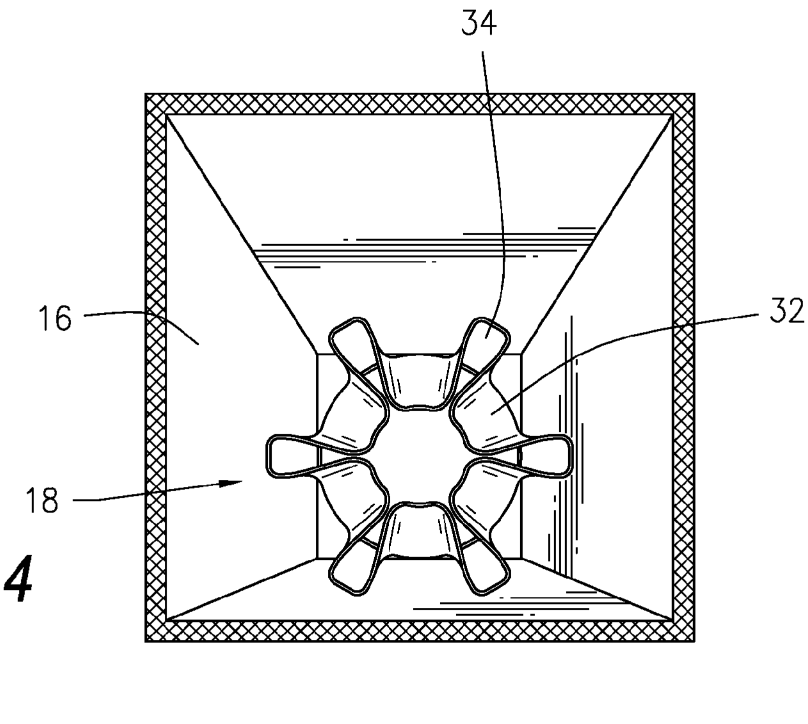


FIG. 4

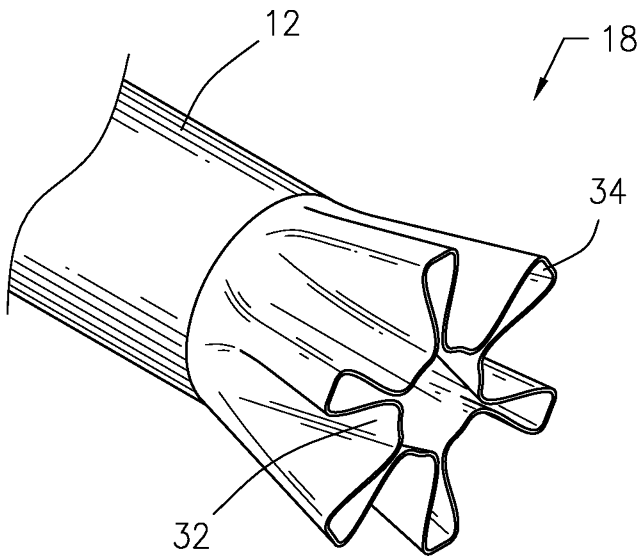


FIG. 5

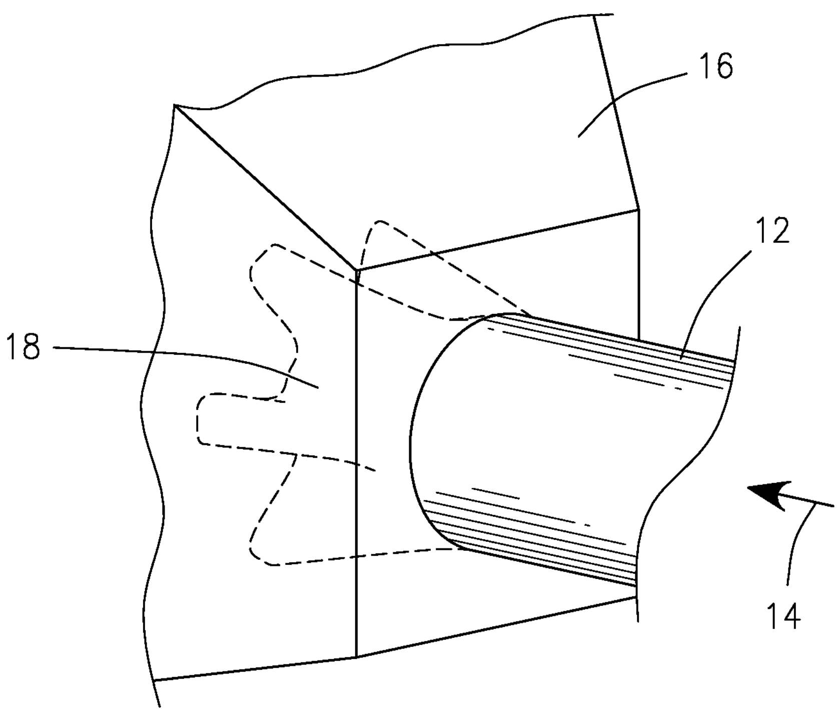


FIG. 6

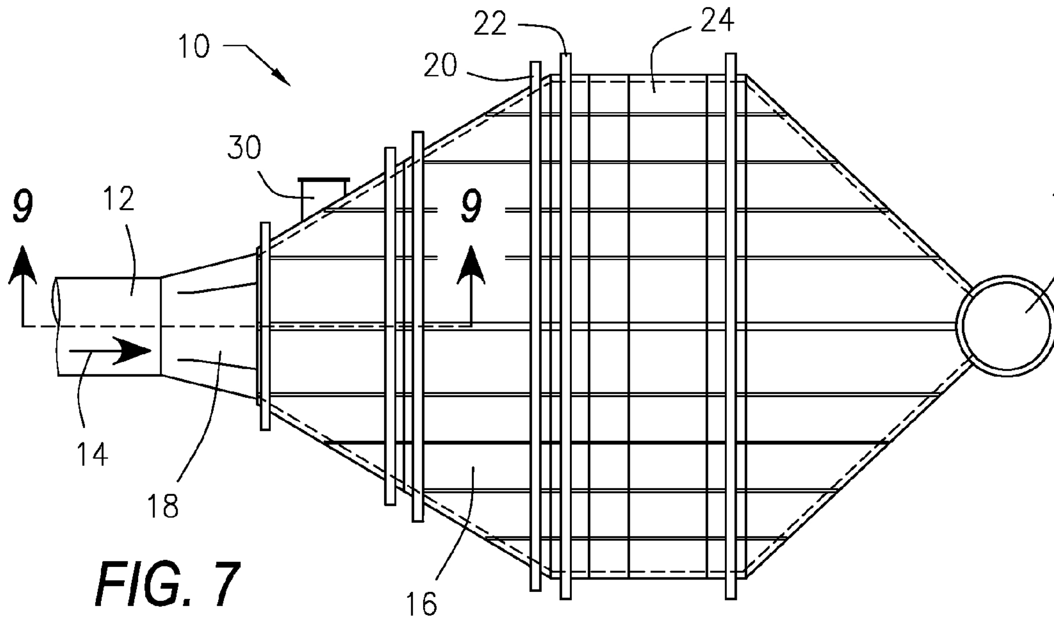


FIG. 7

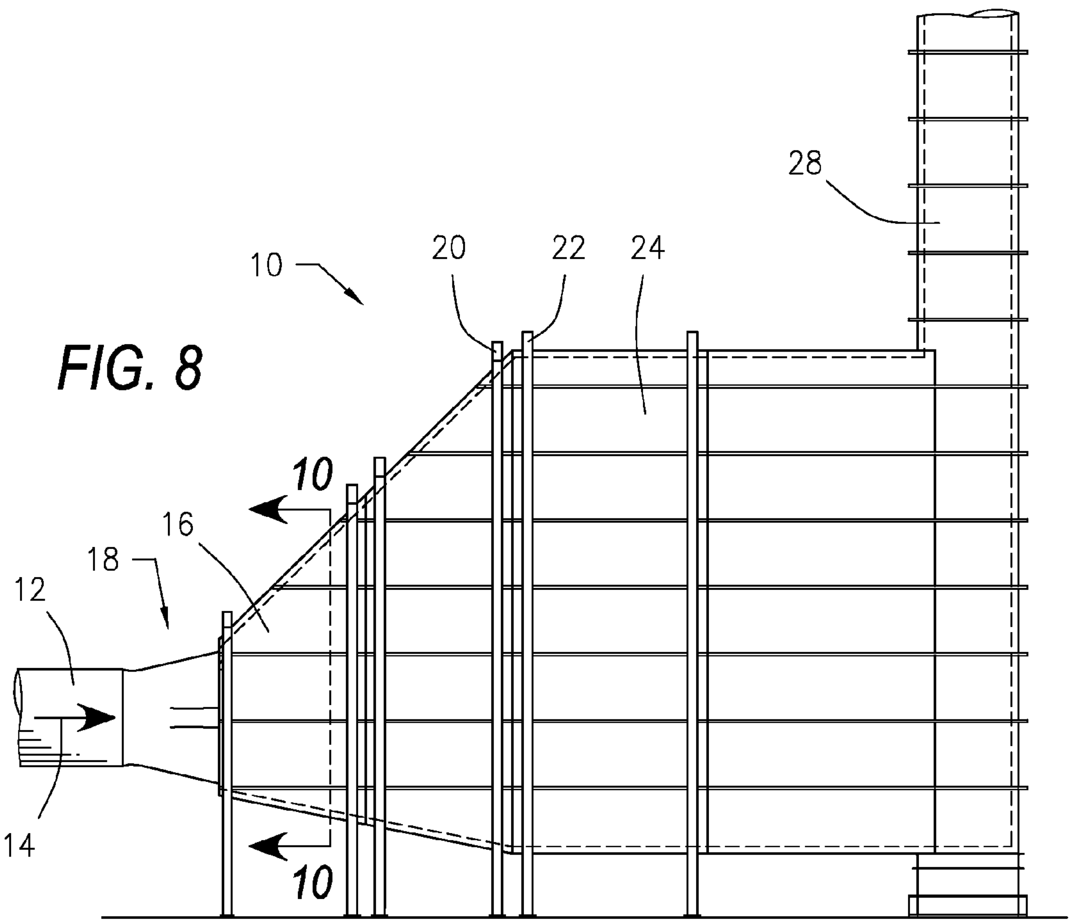


FIG. 8

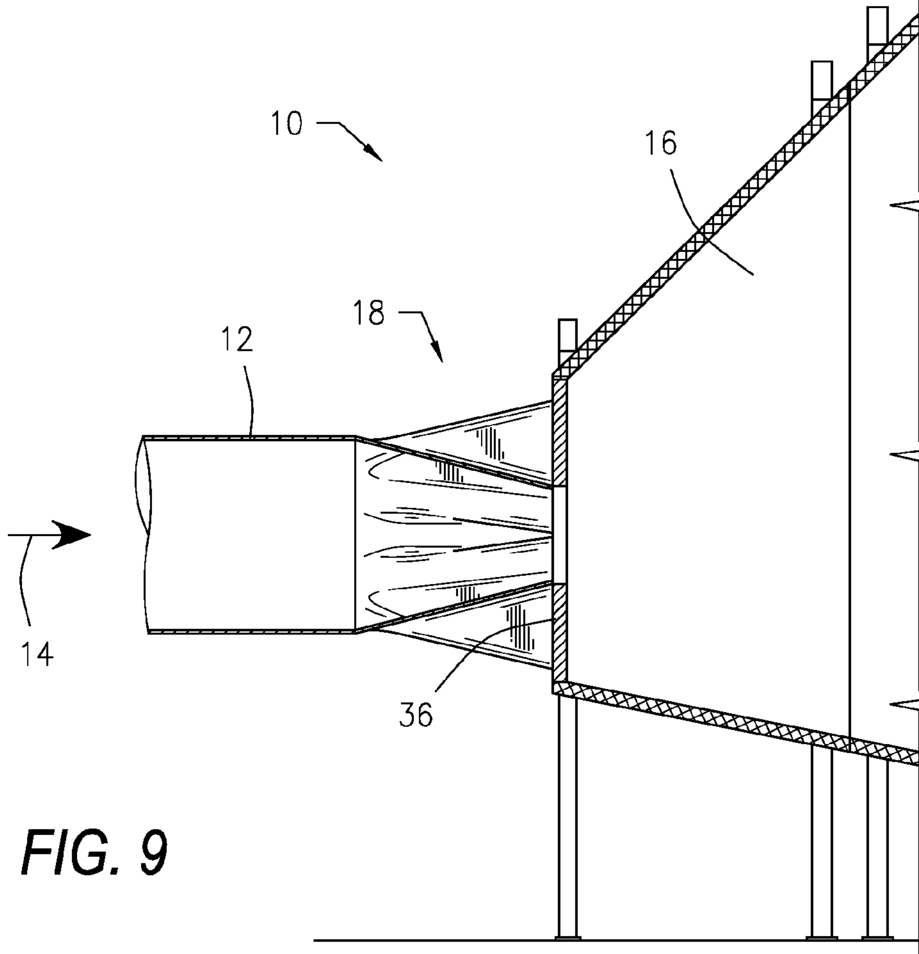


FIG. 9

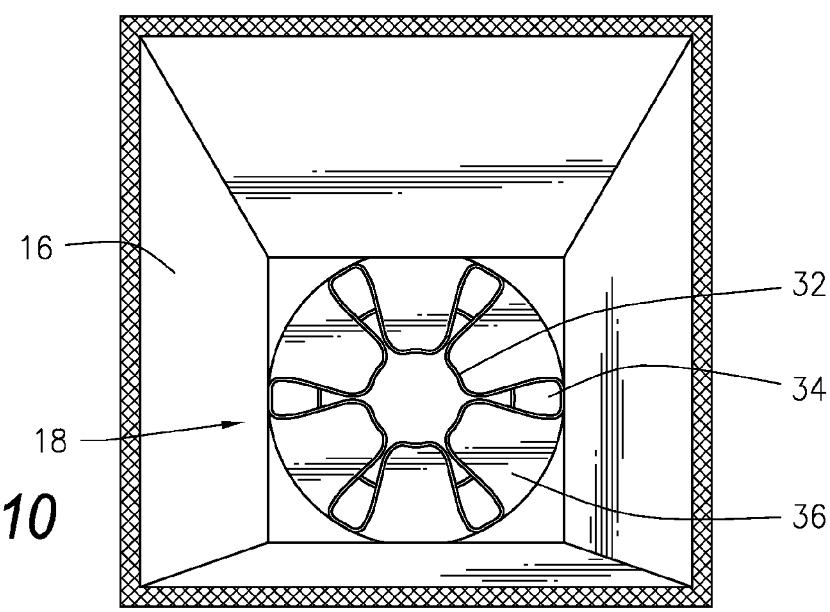


FIG. 10

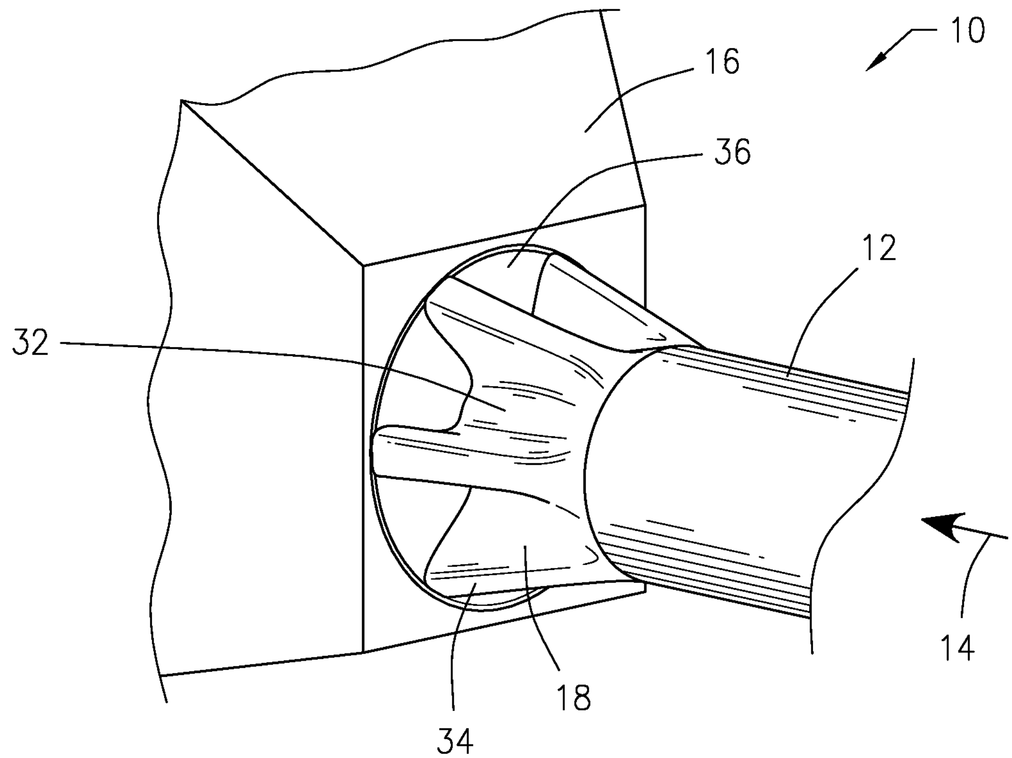


FIG. 11

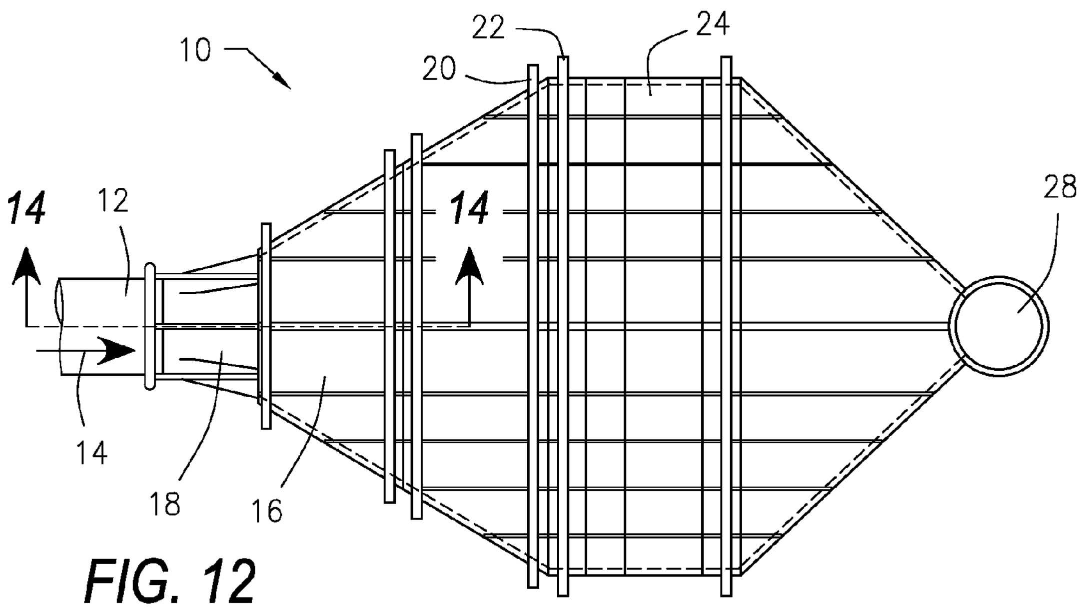


FIG. 12

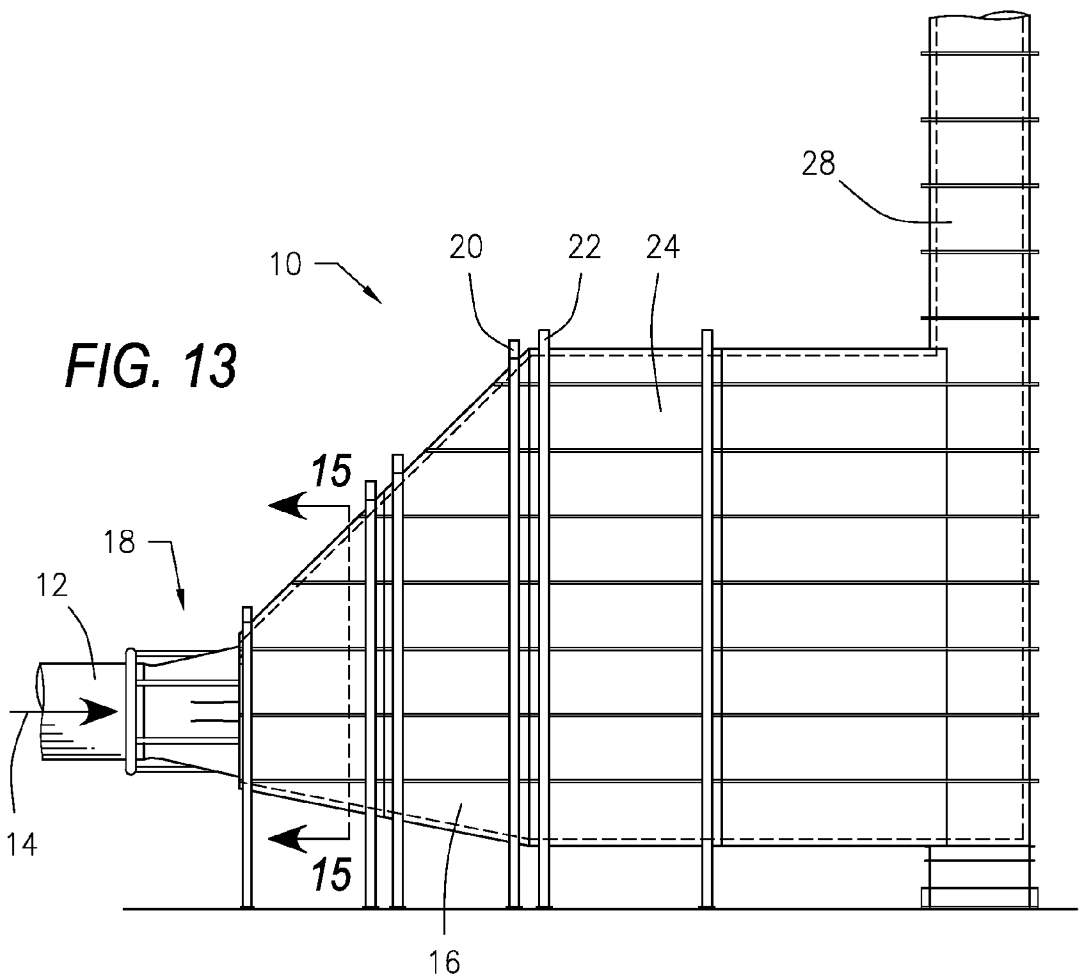


FIG. 13

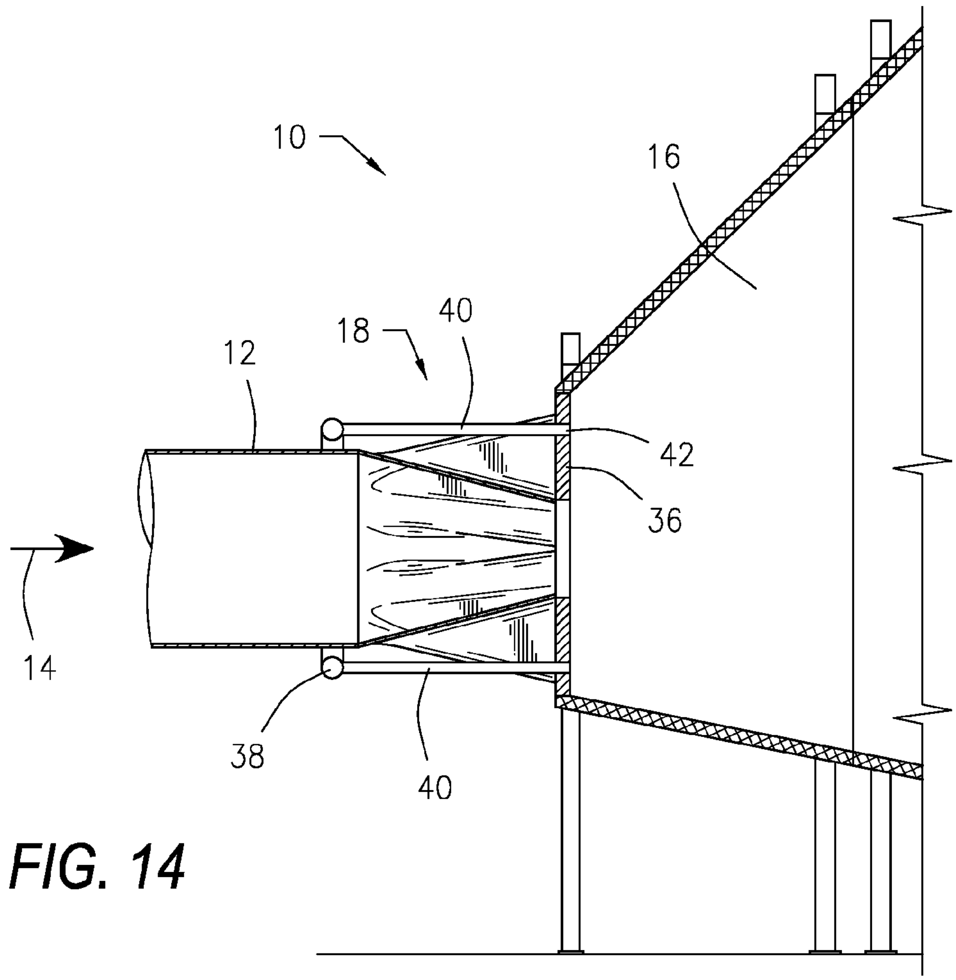
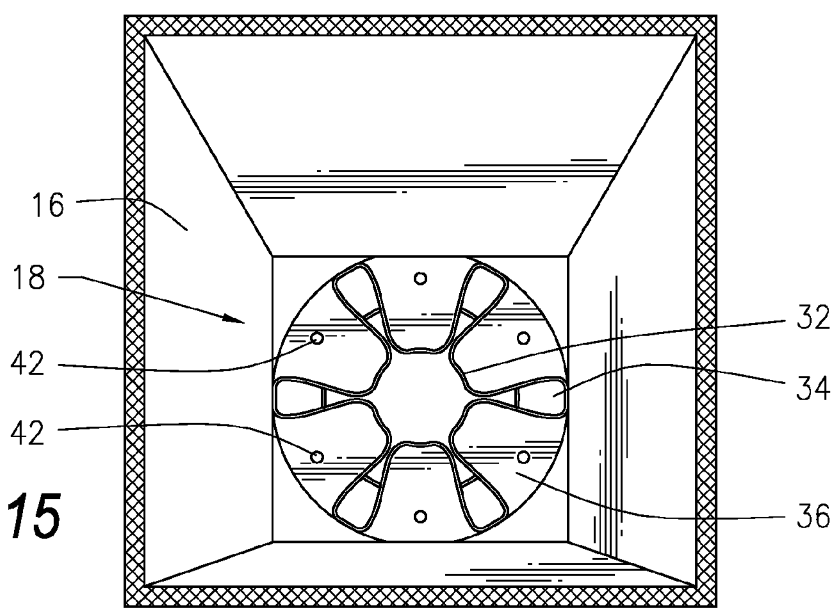


FIG. 14



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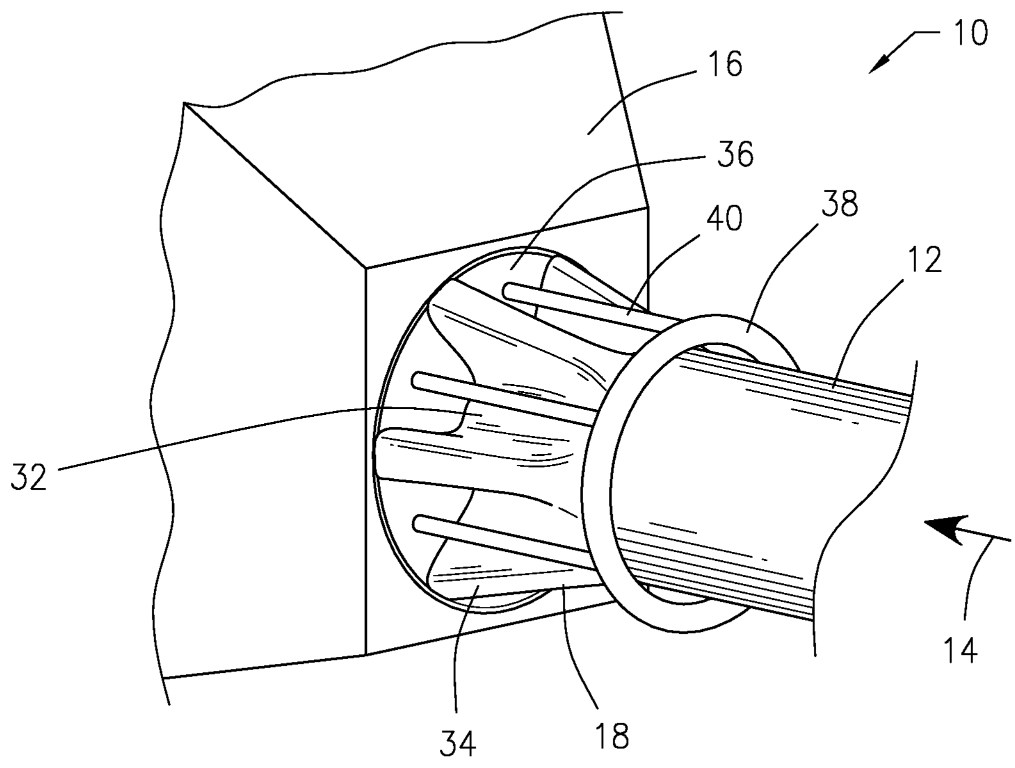


FIG. 16

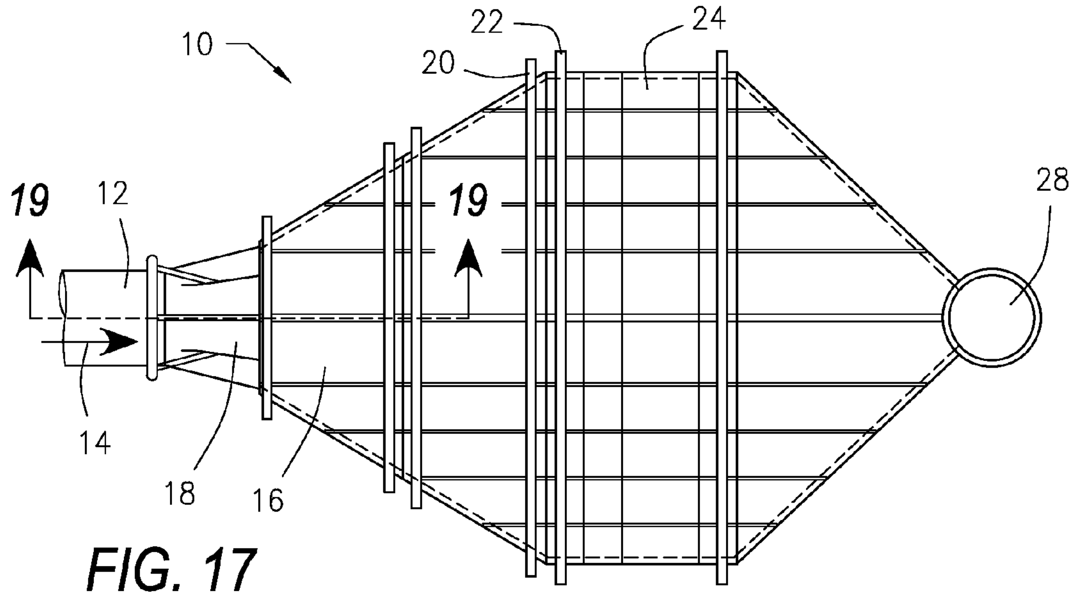
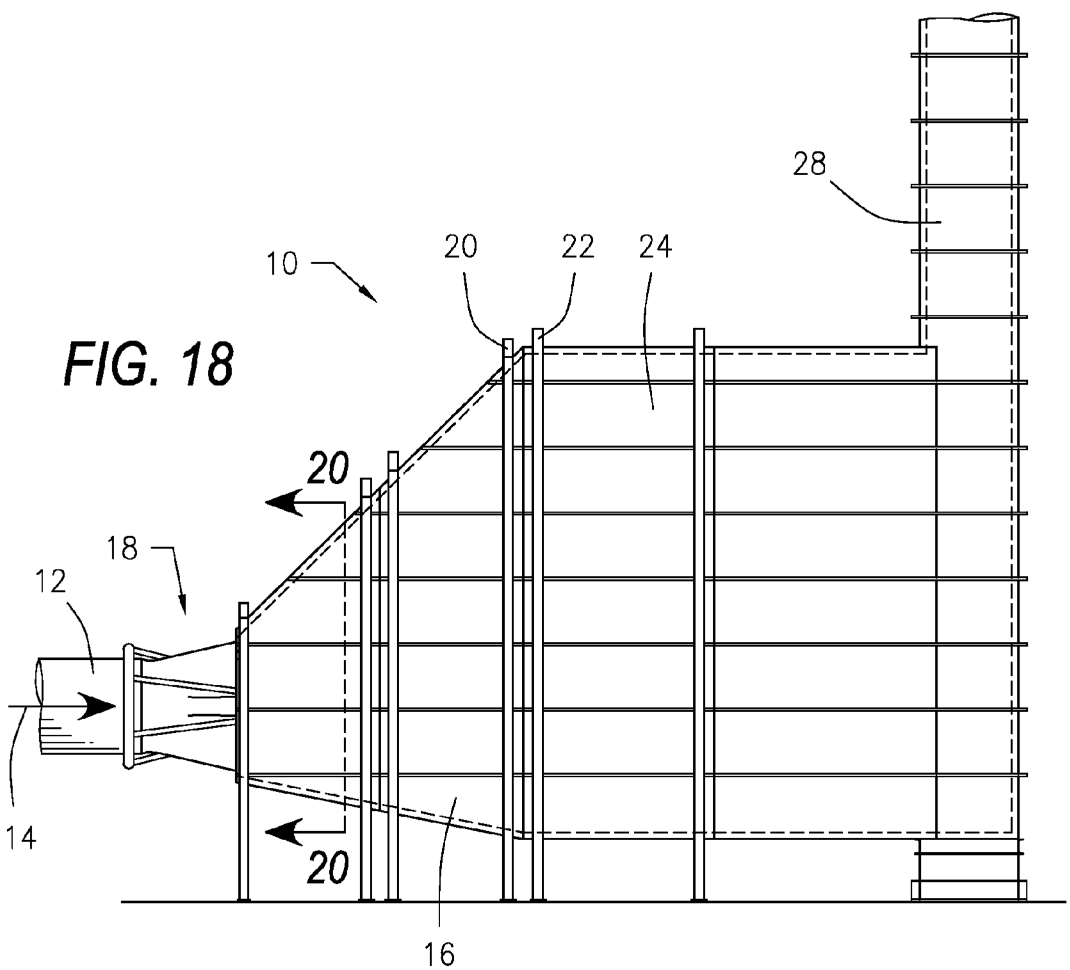


FIG. 17



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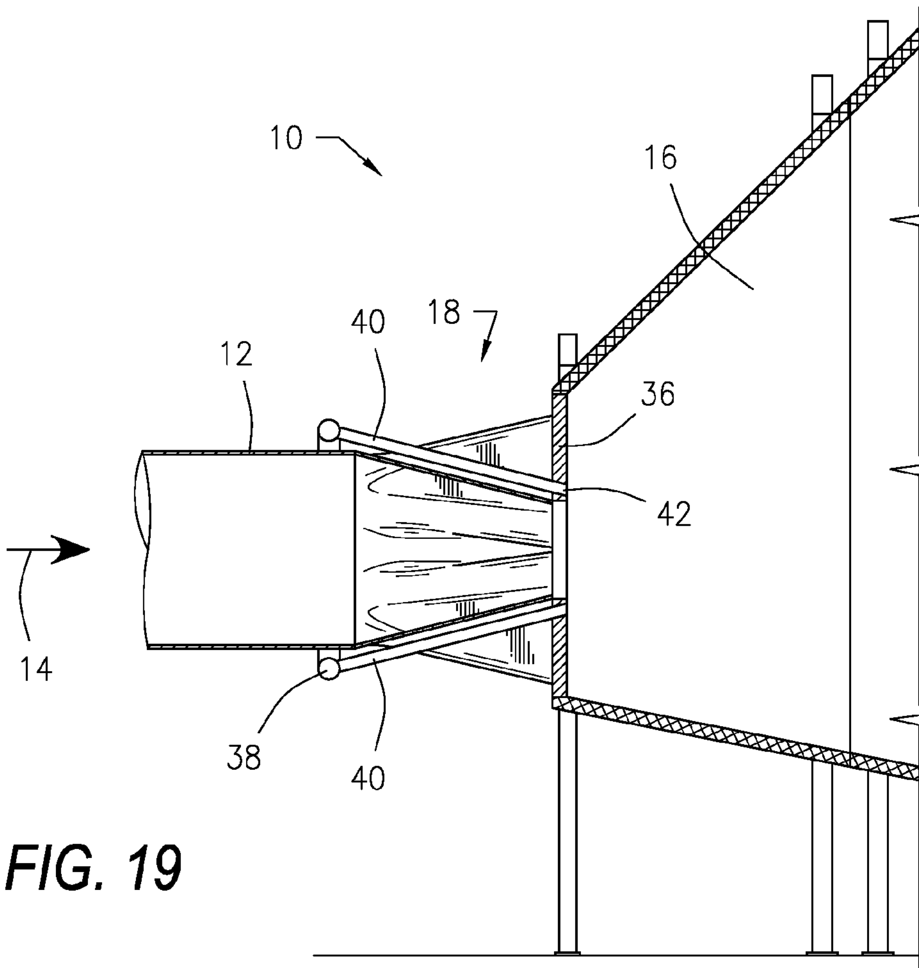

FIG. 19

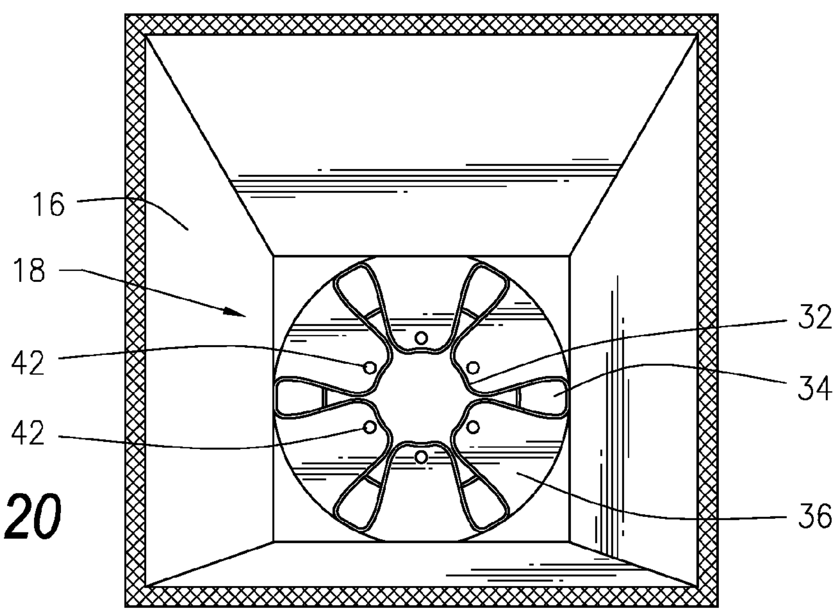

FIG. 20

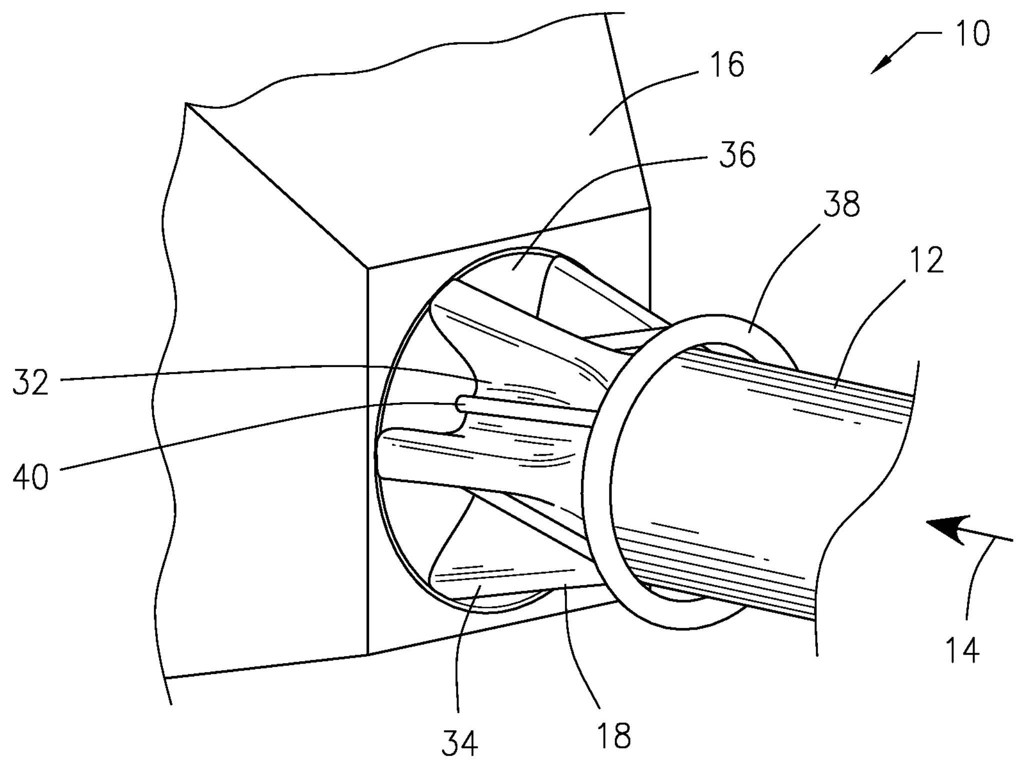

FIG. 21

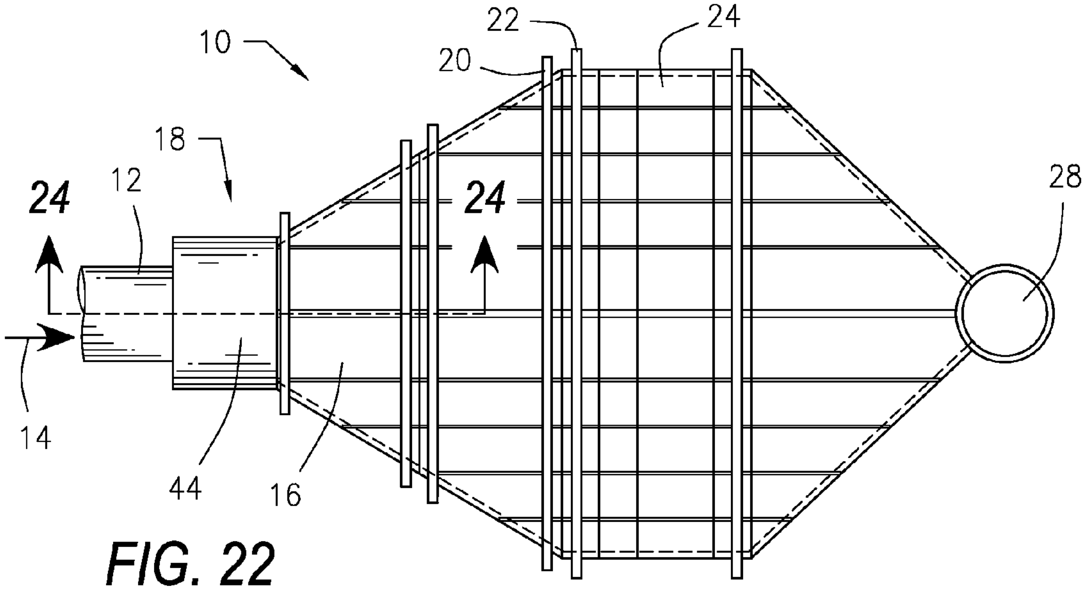
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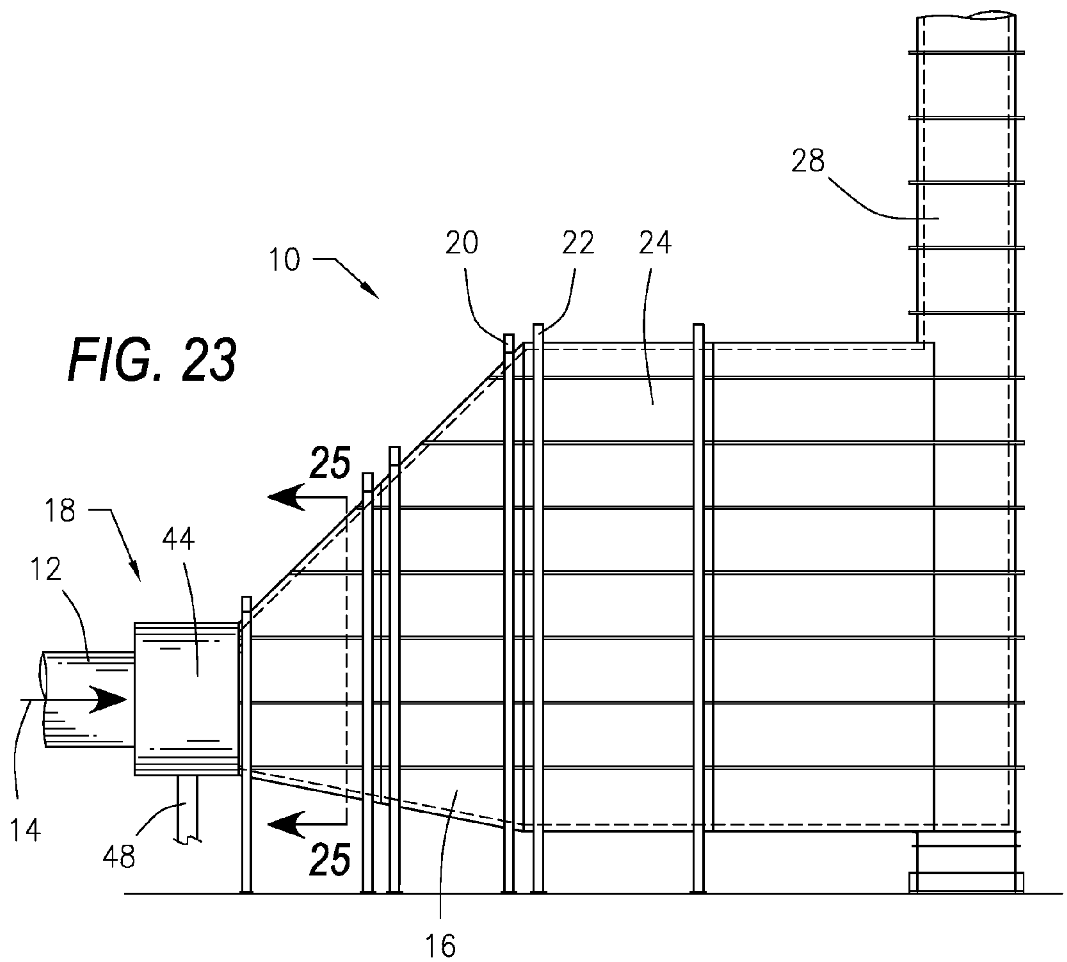
FIG. 22

FIG. 23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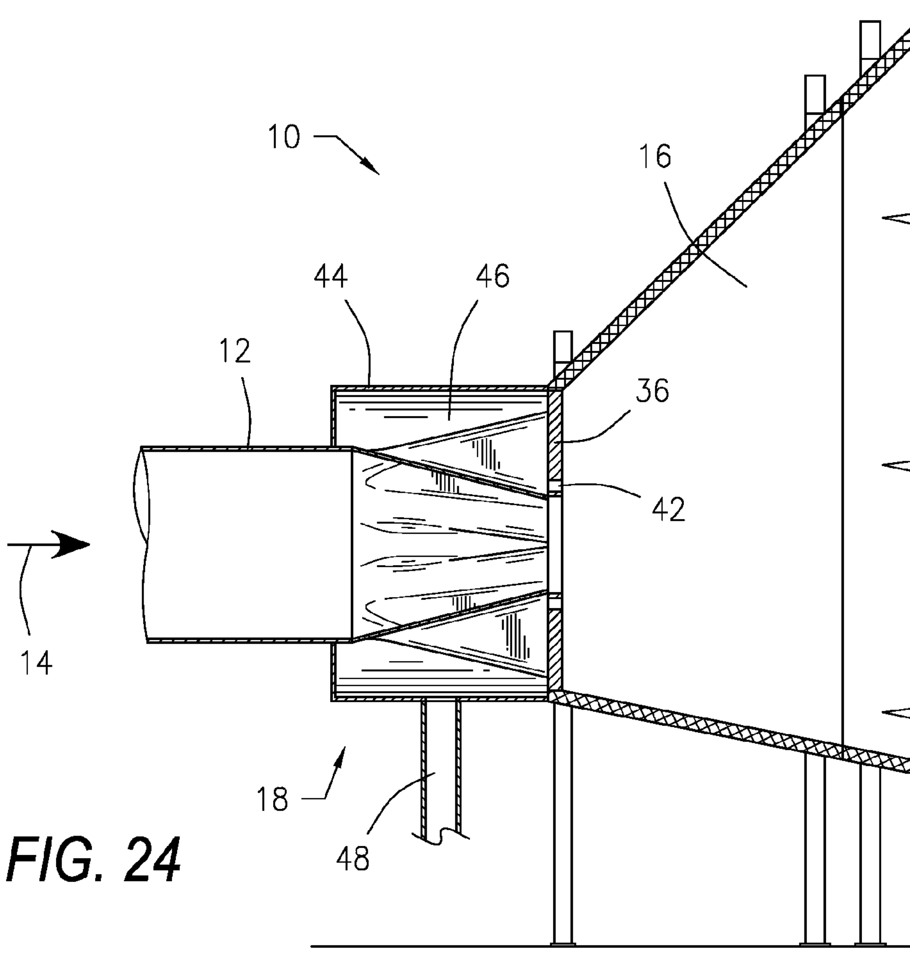

FIG. 24

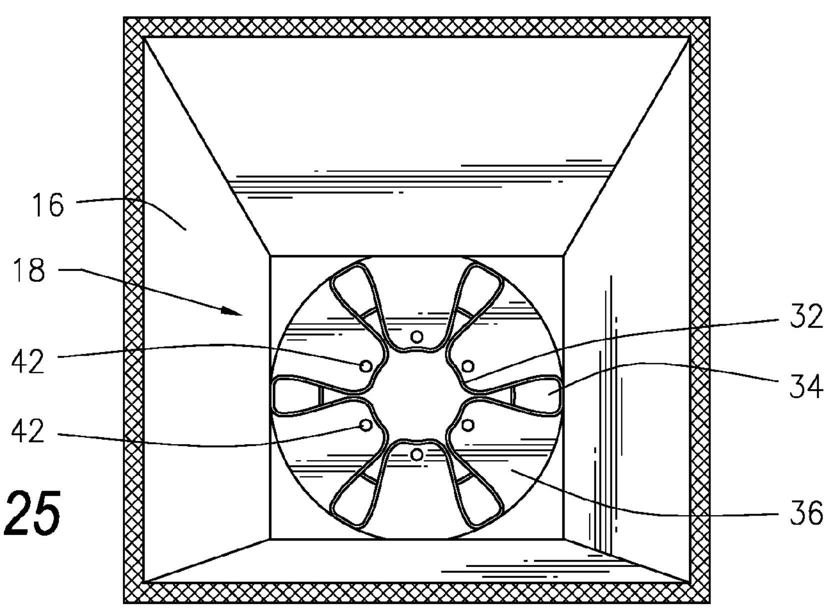

FIG. 25

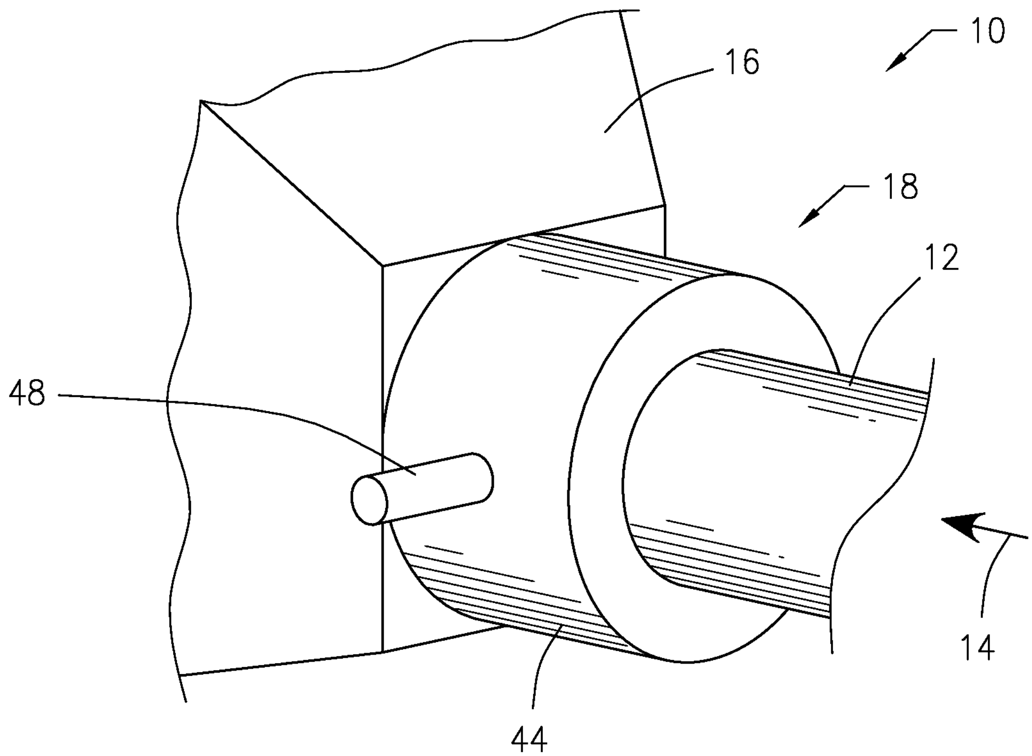

FIG. 26

COMBINED FLOW MIXING, TEMPERING AND NOISE SUPPRESSING APPARATUS FOR A SELECTIVE CATALYTIC REDUCTION SYSTEM AND METHOD OF USE THEREOF

1. Field of the Invention

This invention relates generally to a combined flow mixing, tempering and noise suppressing apparatus for a selective catalytic reduction (SCR) system and method of use thereof, and more particularly to a lobe mixer positioned downstream of a gas input duct of the SCR system in order to provide improved flow uniformity and reduced noise at the entrance to the SCR system with minimal pressure loss.

2. Description of the Related Art

Flue gas waste streams produced from combustion, such as that produced by burning gas, coal, oil, or other carbon-based fuel sources in combustion turbine engines or for other similar uses, typically contain toxic elements, including carbon monoxide (CO) and nitrogen oxide (NO_x). NO_x refers to the cumulative emissions of nitric oxide (NO), nitrogen dioxide (NO_2) and trace quantities of other chemicals during combustion which are environmentally hazardous substances. Combustion of fossil fuels generates some level of NO_x due to high temperatures and availability of oxygen and nitrogen from both the fuel and air. Releasing such combustion waste streams without removing these toxic elements is bad for the environment. Additionally, many places have regulations or laws prohibiting such release. The extent to which CO and NO_x may be released into the environment varies widely under these various laws. California, in particular, has a very high standard regarding such emissions. Therefore, producers of such combustion waste streams frequently must process such waste streams to reduce the amount of toxic elements before releasing the waste streams into the environment. NO_x emissions may be controlled using low NO_x combustion technology and post-combustion techniques, such as selective catalytic reduction. SCR systems catalytically reduce flue gas NO_x to nitrogen and water using ammonia (NH_3) in a chemical reaction.

SCR systems treat the NO_x before the gas is released into the atmosphere. SCR systems rely on a catalyst to treat flue gas as the gas passes through the SCR system. Because the catalyst is an integral part of the SCR chemical reaction, SCR systems attempt to provide maximum exposure of the catalyst to the flue gas in order to ensure that all the flue gas comes sufficiently into contact with the catalyst for treatment. The catalysts used in SCR systems are carefully engineered and expensive. Thus, it is beneficial to be able to control the stoichiometry of the exhaust gas/ammonia/catalyst reaction.

Ammonia injection grids with zone controls have been installed to distribute a prescribed amount of ammonia for NO_x reducing SCR systems. To increase the mixing efficiency and reduce the required mixing distance, many SCR installations are equipped with static mixers. Static mixers typically utilize elaborate designs, are difficult to fabricate, have higher construction and installation costs, and cause significantly higher pressure drop. Static mixers are typically installed between the ammonia injection grid and the SCR catalyst bed; however, deflectors or baffles attached to the injection nozzles or turbulence enhancers installed between the injection tubes have also been utilized.

In the SCR exhaust stack, there is generally a need for noise suppression. Typically, a muffler, also called a silencer, is included in the SCR exhaust stack for noise suppression downstream of the ammonia injection grid and the catalyst bed to provide the required noise suppression. The muffler adds length to the SCR exhaust stack, increases exhaust stack system costs and increases the pressure drop in the stack.

It is therefore desirable to provide a combined flow mixing, tempering and noise suppressing apparatus for an SCR system.

It is also desirable to provide a method of using the apparatus for improved uniformity and noise reduction of a gas waste stream entering the SCR system with minimal pressure loss.

It is further desirable to provide a lobe mixer positioned downstream of a gas input duct of the SCR system in order to provide improved flow uniformity and reduce noise at the entrance to the SCR system.

It is still further desirable to provide a combined flow mixing, tempering and noise suppressing apparatus positioned downstream of a gas input duct and upstream of a catalyst bed in a SCR system to provide improved exhaust flow uniformity, noise suppression and to eliminate the need for a muffler in the exhaust stack in order to provide superior operational efficiency.

It is yet further desirable to provide a combined flow mixing, tempering and noise suppressing apparatus that can include a secondary stream, such as a tempering air, steam or an ammonia-steam mixture, introduced in the lobe depressions of the apparatus.

SUMMARY OF THE INVENTION

In general, in a first aspect, the invention relates to an SCR system having a waste stream gas input duct, an exhaust stack located downstream from the gas input duct and a combined flow mixing, tempering and noise suppressing apparatus positioned downstream from the waste stream gas input duct and upstream from the exhaust stack.

The ammonia injection grid assembly and an SCR catalyst assembly of the SCR system can include one or more of ammonia injection grid assemblies and one or more SCR catalyst assemblies, ordered such that each ammonia injection grid assembly is immediately followed by an SCR catalyst assembly. The SCR system can also include a distribution grid located intermediate of the gas input duct and the ammonia injection grid assembly and the SCR catalyst assembly. In addition, at least one air intake duct may be located intermediate of the gas input duct and the ammonia injection grid assembly and the SCR catalyst assembly and/or may be located upstream from the distribution grid, if present. Additionally, the SCR system can include at least one catalyst bed located downstream from the gas input duct or a plurality of catalyst beds, ordered such that each catalyst bed is immediately followed by an ammonia injection grid assembly.

The combined flow conditioner and noise suppression device of the SCR system can be constructed from a casting of metal, a formed or pressed sheet metal or welded sections of plate and/or can be coated with a refractory material. The combined flow mixing, tempering and noise suppressing apparatus can also include at least one lobe depression that extends toward a centerline axis of the gas input duct and at least one alternating lobe protrusion leading away from the centerline axis. Further, the combined flow mixing, tempering and noise suppressing apparatus can be a lobe mixer having six lobe depressions and six lobe protrusions in a sinusoidal profile.

The combined flow mixing, tempering and noise suppressing apparatus can be positioned internally within the SCR system or positioned externally at an entrance to the SCR system. The combined flow mixing, tempering and noise suppressing apparatus can also include a toroidal air manifold having a plurality of air manifold pipes. The manifold pipes are in fluid communication with the SCR system, such as via circumferentially spaced ports of a circular plate. The manifold pipes can be positioned substantially parallel with respect to the flow of the waste stream, or can be positioned at an angle with respect to the flow of the waste stream. Alternatively, the combined flow mixing, tempering and noise suppressing apparatus can include a hollow annular air bustle forming a chamber to which a secondary stream under pressure is supplied. The chamber of the air bustle is in fluid communication with the SCR system, such as via circumferentially spaced ports of a circular plate.

In general, in a second aspect, the invention relates to a SCR system having a gas input duct, a catalyst bed located downstream from the gas input duct, an ammonia injection grid assembly and an SCR catalyst assembly located downstream from the catalyst bed, and an exhaust stack located downstream from the catalyst bed, the ammonia injection grid assembly and the SCR catalyst assembly. The SCR system includes a combined flow mixing, tempering and noise suppressing apparatus located downstream from the gas input duct and upstream from the catalyst bed.

The combined flow conditioner and noise suppression device of the SCR system can be constructed from a casting of metal, a formed or pressed sheet metal or welded sections of plate and/or can be coated with a refractory material. The combined flow mixing, tempering and noise suppressing apparatus can also have at least one lobe depression that extends toward a centerline axis of the gas input duct and at least one alternating lobe protrusion leading away from the centerline axis. Further, the combined flow mixing, tempering and noise suppressing apparatus can be a lobe mixer having six lobe depressions and six lobe protrusions in a sinusoidal profile.

The combined flow mixing, tempering and noise suppressing apparatus can be positioned internally within the SCR system or positioned externally at an entrance to the SCR system. The combined flow mixing, tempering and noise suppressing apparatus can also include a toroidal air manifold having a plurality of air manifold pipes. The manifold pipes are in fluid communication with the SCR system, such as via circumferentially spaced ports of a circular plate. The manifold pipes can be positioned substantially parallel with respect to the flow of the waste stream, or can be positioned at an angle with respect to the flow of the waste stream. Alternatively, the combined flow mixing, tempering and noise suppressing apparatus can include a hollow annular air bustle forming a chamber to which a secondary stream under pressure is supplied. The chamber of the air bustle is in fluid communication with the SCR system, such as via circumferentially spaced ports of a circular plate.

In general, in a third aspect, the invention relates to a combined flow mixing, tempering and noise suppressing apparatus for a SCR system. The SCR system has a gas input duct, a catalyst bed located downstream from the gas input duct, an ammonia injection grid assembly and an SCR catalyst assembly located downstream from the catalyst bed, and an exhaust stack located downstream from the ammonia injection grid assembly and the SCR catalyst assembly. The combined flow mixing, tempering and noise suppressing apparatus includes a lobe mixer positioned downstream from the gas input duct and upstream from the catalyst bed in the SCR system. The lobe mixer has lobe depressions that extend toward a centerline axis of the gas input duct and alternating lobe protrusions leading away from the centerline axis.

The combined flow conditioner and noise suppression device of the SCR system can be constructed from a casting of metal, a formed or pressed sheet metal or welded sections of plate and/or can be coated with a refractory material. Further, the combined flow mixing, tempering and noise suppressing apparatus can be a lobe mixer having six lobe depressions and six lobe protrusions in a sinusoidal profile. The combined flow mixing, tempering and noise suppressing apparatus can also include a toroidal air manifold having a plurality of air manifold pipes. The manifold pipes are in fluid communication with the SCR system. The manifold pipes can be positioned substantially parallel with respect to the flow of the waste stream, or can be positioned at an angle with respect to the flow of the waste stream. Alternatively, the combined flow mixing, tempering and noise suppressing apparatus can include a hollow annular air bustle forming a chamber to which a secondary stream under pressure is supplied. The chamber of the air bustle is in fluid communication with the SCR system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view of an SCR system having an example of an internal lobe mixer positioned downstream of a gas input duct, within the SCR system and upstream of a catalyst bed in accordance with an illustrative embodiment of the combined flow mixing, tempering and noise suppressing apparatus for the SCR system disclosed herein;

FIG. **2** is a plan view of the SCR system shown in FIG. **1**;

FIG. **3** is a cross-sectional view along line **3-3** of the SCR system shown in FIG. **1**;

FIG. **4** is a cross-sectional view along line **4-4** of the SCR system shown in FIG. **2**;

FIG. **5** is a perspective view of the internal lobe mixer shown in FIGS. **1** through **4**;

FIG. **6** is a partial cutaway view of the internal lobe mixer shown in FIGS. **1** through **5** positioned within the SCR system;

FIG. **7** is an elevation view of an SCR system having an example of an external lobe mixer positioned downstream of a gas input duct in accordance with an illustrative embodiment of the combined flow mixing, tempering and noise suppressing apparatus for the SCR system disclosed herein;

FIG. **8** is a plan view of the SCR system shown in FIG. **7**;

FIG. **9** is a cross-sectional view along line **9-9** of the SCR system shown in FIG. **7**;

FIG. **10** is a cross-sectional view along line **10-10** of the SCR system shown in FIG. **8**;

FIG. **11** is a rear perspective view of the external lobe mixer shown in FIGS. **7** through **10**;

FIG. **12** is an elevation view of an SCR system having an example of an external lobe mixer having a straight air manifold and positioned downstream of a gas input duct in accordance with an illustrative embodiment of the combined flow mixing, tempering and noise suppressing apparatus for the SCR system disclosed herein;

FIG. **13** is a plan view of the SCR system shown in FIG. **12**;

FIG. **14** is a cross-sectional view along line **14-14** of the SCR system shown in FIG. **12**;

FIG. **15** is a cross-sectional view along line **15-15** of the SCR system shown in FIG. **13**;

FIG. **16** is a rear perspective view of the external lobe mixer having the straight air manifold shown in FIGS. **12** through **15**;

FIG. **17** is an elevation view of an SCR system having an example of an external lobe mixer having an angled air manifold in accordance with an illustrative embodiment of the combined flow mixing, tempering and noise suppressing apparatus for the SCR system disclosed herein;

FIG. **18** is a plan view of the SCR system shown in FIG. **17**;

FIG. **19** is a cross-sectional view along line **19-19** of the SCR system shown in FIG. **17**;

FIG. **20** is a cross-sectional view along line **20-20** of the SCR system shown in FIG. **18**;

FIG. **21** is a rear perspective view of the external lobe mixer having the angled air manifold shown in FIG. **17** through;

FIG. **22** is an elevation view of an SCR system having an example of an external lobe mixer having an air bustle in accordance with an illustrative embodiment of the combined flow mixing, tempering and noise suppressing apparatus for the SCR system disclosed herein;

FIG. **23** is a plan view of the SCR system shown in FIG. **22**;

FIG. **24** is a cross-sectional view along line **24-24** of the SCR system shown in FIG. **22**;

FIG. **25** is a cross-sectional view along line **25-25** of the SCR system shown in FIG. **23**; and

FIG. **26** is a rear perspective view of the external lobe mixer having the air bustle shown in FIGS. **22** through **25**.

Other advantages and features will be apparent from the following description and from the claims.

DETAILED DESCRIPTION OF THE INVENTION

The apparatuses and methods discussed herein are merely illustrative of specific manners in which to make and use this invention and are not to be interpreted as limiting in scope.

While the apparatuses and methods have been described with a certain degree of particularity, it is to be noted that many modifications may be made in the details of the construction and the arrangement of the apparatuses and components without departing from the spirit and scope of this disclosure. It is understood that the apparatuses and methods are not limited to the embodiments set forth herein for purposes of exemplification.

Referring to the figures of the drawings, wherein like numerals of reference designate like elements throughout the several views, and initially referring to FIGS. **1** and **2**, the SCR system **10** includes a gas input duct **12**, wherein a flue gas waste stream (arrow **14**) from combustion enters the SCR system **10**. Downstream from the gas input duct **12** may be a distribution grid **16**. The distribution grid **16** axially distributes the waste stream **14** so as to limit the pressure drop on the successive elements. Downstream from the gas input duct **12** and the distribution grid **16**, if it is present, is a catalyst bed **20**. The catalyst bed **20** removes carbon monoxide from the waste stream **14**.

The combined flow mixing, tempering and noise suppressing apparatus **18** is positioned downstream from the gas input duct **12**, and aides in limiting the pressure drop by conditioning the flow of the waste stream **14**. The combined flow conditioner and noise suppressing apparatus **18** is positioned upstream of the catalyst bed **20** in the SCR system **10**, thereby improving the SCR system's **10** efficiency and reducing sound pollution. The combined flow conditioner and noise suppressing apparatus **18** can be a lobe mixer, as exemplified in the figures.

Downstream from the catalyst bed **20** is at least one ammonia injection grid assembly **22**, followed by at least one SCR catalyst assembly **24**. The ammonia injection grid assembly **22** and the SCR catalyst assembly **24** work in conjunction to remove NO_x present in the waste stream **14**. Downstream from the ammonia injection grid assembly **22** and the SCR catalyst assembly **24** could be additional ammonia injection grid assemblies and/or SCR catalyst assemblies to remove additional NO_x remaining in the waste stream **14**.

Downstream from the SCR catalyst assembly **24** is an exhaust stack **28** whereby the treated flue gas waste stream **14** exits the SCR system **10**. The combined flow mixing, tempering and noise suppressing apparatus **18** provides noise suppression and eliminates the need for a muffler or silencer in the SCR exhaust stack **28**. This allows the SCR system **10** to be used in locations where sound pollution is a concern. Further, by eliminating the need for a muffler in the SCR exhaust stack **28**, the SCR exhaust stack **28** requires less space, is less expensive and has less pressure loss for a more effective exhaust system.

The combined flow mixing, tempering and noise suppressing apparatus **18** decreases shear and increases mixing as the waste stream **14** enters the gas input duct **12** of the SCR system **10**. (The combined flow mixing, tempering and noise suppressing apparatus **18** partially preconditions the waste stream **14** to a predetermined profile for introduction into the SCR system. The suppressing apparatus rapidly mixes the waste stream **14** with gases already present in the gas input duct **12**, or gases introduced using a secondary stream, in order to reduce the density gradient between the waste stream **14** and the SCR gases, which reduces the generation of noise.) Further, the combined flow mixing, tempering and noise suppressing apparatus **18** provides a well-mixed, evenly tempered waste stream **14** in the SCR system **10** so as to prolong the life of the catalysts of the catalyst bed **20**.

The combined flow mixing, tempering and noise suppressing apparatus **18** can be constructed of any suitable materials, such as a casting of metal, formed (pressed) sheet metal, or welded sections of plate. In addition, the combined flow mixing, tempering and noise suppressing apparatus **18** may be coated with a refractory material. The combined flow mixing, tempering and noise suppressing apparatus **18** includes at least one lobe portion **32** that extends toward the centerline axis of the gas input duct **12** with at least one alternating lobe portion **34** leading away from the centerline axis. As exemplified throughout the figures, the combined flow mixing, tempering and noise suppressing apparatus **18** is a lobe mixer having six (6) lobes in a sinusoidal profile, but a person having ordinary skill in the art will readily appreciate that other profiles are possible.

As illustrated in FIGS. **1** through **6**, the combined flow mixing, tempering and noise suppressing apparatus **18** is positioned downstream of the gas input duct **12**, upstream of the catalyst bed **20** and within the distribution grid **16**. In this example, the combined flow mixing, tempering and noise suppressing apparatus **18** does not include a secondary stream, but the SCR system **10** may have at least one air intake duct **30** located downstream from both the gas input duct **12** and the combined flow mixing, tempering and noise suppressing apparatus **18** and upstream of the catalyst bed **20**. This allows a secondary stream of tempering air, steam or an ammonia-steam mixture to be added to the combustion waste stream **14**. Connected to the air intake duct **30** may be a fan (not shown), and the air flow from the fan may be controlled by a damper (not shown), which may be located adjacent the air intake duct **30**. The fan allows tempering air to be forcibly added to the combustion waste stream **14**, and the damper allows a user to control the amount of air allowed to pass through the air intake duct **30**.

Referring now to FIGS. **7** through **11**, the combined flow mixing, tempering and noise suppressing apparatus **18** is positioned at the entrance of the SCR system **10**, in particular, downstream of the gas input duct **12** and upstream of the distribution grid **16** and the catalyst bed **20**. As exemplified in this example, the forwardly disposed terminal ends of the lobe portion **32** and the lobe portion **34** of the combined flow mixing, tempering and noise suppressing apparatus **18** abuts and is attached to a rearwardly disposed face of a circular plate **36**. Similar to above, the combined flow mixing, tempering and noise suppressing apparatus **18** in this example does not include a secondary stream, but the SCR system **10** includes the air intake duct **30** located downstream from the combined flow mixing, tempering and noise suppressing apparatus **18**, within the distribution grid **16** and upstream of the catalyst bed **20**.

Referring now to the two examples of the combined flow mixing, tempering and noise suppressing apparatus **18** illustrated in FIGS. **12** through **16** and in FIGS. **17** through **21**, the SCR system **10** includes the combined flow mixing, tempering and noise suppressing apparatus **18** positioned intermediate of the gas input duct **12** and the distribution grid **16**. The forwardly disposed terminal ends of the lobe portion **32** and the lobe portion **34** of the combined flow mixing, tempering and noise suppressing apparatus **18** abuts and is attached to the rearwardly disposed face of the plate **36**.

In these examples, the combined flow mixing, tempering and noise suppressing apparatus **18** includes a means of introducing the secondary stream into the SCR system for mixing with the waste stream **14**, such as by means of a toroidal air manifold **38** having a plurality of air manifold pipes **40** circumferentially spaced and in fluid communication with circumferentially spaced ports **42** in the plate **36**. As can be seen in FIGS. **14** and **16**, the manifold pipes **40** may be positioned substantially parallel with respect to the plane of the flow of the waste stream **14**, and are positioned within the lobe portions **32**. Alternatively as can be seen in FIGS. **19** and **21**, the manifold pipes may be positioned at an angle with respect to the flow of the waste stream **14** so as to cause an angular impingement of the secondary stream with the flow of the waste stream **14**. The secondary stream is introduced to the air manifold **38** which blows downstream in the direction of the distribution grid **16**. The secondary stream penetrates the ports **42** in the plate **36** where it is added to the waste stream **14**, where the suppressing apparatus **18** effectively mixes and conditions the waste stream **14** and the SCR gases to reduce the generation of noise in the SCR system **10**.

Turning now to FIGS. **22** through **26**, the combined flow mixing, tempering and noise suppressing apparatus **18** may include a hollow annular air bustle **44** forming a chamber **46** to which the secondary stream under pressure is supplied from a pipe **48**. In order to admit the secondary stream from the air bustle **44** into the SCR system **10**, ports **42** are provided in the plate **36** suitably arranged, such as circumferentially spaced, so as to afford fluid communication between the air bustle **44** and the SCR system **10**. A forwardly disposed wall of the air bustle **44** abuts and is attached to the rearwardly disposed face of the circular plate **36**. The secondary stream is introduced into the chamber **46** of the air bustle **44** and blows downstream to penetrate the ports **42** in the plate **36**. The combined flow mixing, tempering and noise suppressing apparatus **18** mixes the secondary stream with the waste stream **14** to improve the flow uniformity and to reduce the noise at the gas input duct **12** of the SCR system **10** with minimal pressure loss.

Whereas, the apparatuses and methods have been described in relation to the drawings and claims, it should be understood that other and further modifications, apart from those shown or suggested herein, may be made within the scope of this invention.

What is claimed is:

1. A selective catalytic reduction system, comprising:

a waste stream gas input duct;

an exhaust stack located downstream from said gas input duct; and

a combined flow mixing, tempering and noise suppressing apparatus positioned downstream from said waste stream gas input duct and upstream from said exhaust stack wherein said combined flow mixing, tempering and noise suppressing apparatus further comprises a toroidal air manifold having a plurality of air manifold pipes or a hollow annular air bustle forming a chamber to which a secondary stream under pressure is supplied.

2. The selective catalytic reduction system of claim **1** further comprising at least one ammonia injection grid assembly and at least one selective catalytic reduction catalyst assembly, ordered such that each ammonia injection grid assembly is immediately followed by a selective catalytic reduction catalyst assembly.

3. The selective catalytic reduction system of claim **2** further comprising a distribution grid located intermediate of said gas input duct and said ammonia injection grid assembly and said selective catalytic reduction catalyst assembly.

4. The selective catalytic reduction system of claim **2** further comprising at least one air intake duct located downstream of said gas input duct and said combined flow mixing, tempering and noise suppressing apparatus and upstream of said ammonia injection grid assembly and said selective catalytic reduction catalyst assembly.

5. The selective catalytic reduction system of claim **3** further comprising at least one air intake duct located downstream of said gas input duct and said combined flow mixing, tempering and noise suppressing apparatus upstream from said distribution grid.

6. The selective catalytic reduction system of claim **1** further comprising at least one catalyst bed located downstream from said gas input duct.

7. The selective catalytic reduction system of claim **6** further comprising a plurality of catalyst beds, ordered such that each catalyst bed is immediately followed by an ammonia injection grid assembly.

8. The selective catalytic reduction system of claim **1** wherein said combined flow mixing, tempering and noise suppressing apparatus comprises a lobe mixer.

9. The selective catalytic reduction system of claim **1** wherein said combined flow mixing, tempering and noise suppressing apparatus is constructed from a casting of metal, a formed or pressed sheet metal or welded sections of plate.

10. The selective catalytic reduction system of claim **1** wherein said combined flow mixing, tempering and noise suppressing apparatus is coated with a refractory material.

11. The selective catalytic reduction system of claim **1** wherein said combined flow mixing, tempering and noise suppressing apparatus comprises at least one lobe depression that extends toward a centerline axis of said gas input duct and at least one alternating lobe protrusion leading away from said centerline axis.

12. The selective catalytic reduction system of claim **11** wherein said combined flow mixing, tempering and noise suppressing apparatus comprises a lobe mixer having six lobe depressions and six lobe protrusions in a sinusoidal profile.

13. The selective catalytic reduction system of claim **1** wherein said combined flow mixing, tempering and noise suppressing apparatus is positioned internally within said selective catalytic reduction system.

14. The selective catalytic reduction system of claim **1** wherein said combined flow mixing, tempering and noise suppressing apparatus is positioned externally at an entrance to said selective catalytic reduction system.

15. The selective catalytic reduction system of claim **1** wherein said manifold pipes are in fluid communication with said selective catalytic reduction system via circumferentially spaced ports.

16. The selective catalytic reduction system of claim **1** wherein said manifold pipes are positioned substantially parallel with respect to the flow of said waste stream.

17. The selective catalytic reduction system of claim **1** wherein said manifold pipes are positioned at an angle with respect to the flow of said waste stream.

18. The selective catalytic reduction system of claim **1** wherein said chamber of said air bustle is in fluid communication with said selective catalytic reduction system via circumferentially spaced ports.

19. A selective catalytic reduction system comprising a gas input duct, a catalyst bed located downstream from said gas input duct, an ammonia injection grid assembly and a selective catalytic reduction catalyst assembly located downstream from said catalyst bed, and an exhaust stack located downstream from said catalyst bed, said ammonia injection grid assembly and said selective catalytic reduction catalyst assembly, said selective catalytic reduction system further comprising:

a combined flow mixing, tempering and noise suppressing apparatus located downstream from said gas input duct and upstream from said catalyst bed wherein said combined flow mixing, tempering and noise suppressing apparatus further comprises a toroidal air manifold having a plurality of air manifold pipes or a hollow annular air bustle forming a chamber to which a secondary stream under pressure is supplied.

20. The selective catalytic reduction system of claim **19** wherein said combined flow mixing, tempering and noise suppressing apparatus comprises a lobe mixer.

21. The selective catalytic reduction system of claim **19** wherein said combined flow mixing, tempering and noise suppressing apparatus is constructed from a casting of metal, a formed or pressed sheet metal or welded sections of plate.

22. The selective catalytic reduction system of claim **19** wherein said combined flow mixing, tempering and noise suppressing apparatus is coated with a refractory material.

23. The selective catalytic reduction system of claim **19** wherein said combined flow mixing, tempering and noise suppressing apparatus comprises lobe depressions that extend toward a centerline axis of said gas input duct and alternating lobe protrusions leading away from said centerline axis.

24. The selective catalytic reduction system of claim **23** wherein said combined flow mixing, tempering and noise suppressing apparatus comprises a lobe mixer having six lobe depressions and six lobe protrusions in a sinusoidal profile.

25. The selective catalytic reduction system of claim **19** wherein said combined flow mixing, tempering and noise suppressing apparatus is positioned internally within said selective catalytic reduction system.

26. The selective catalytic reduction system of claim **19** wherein said combined flow mixing, tempering and noise suppressing apparatus is positioned externally at an entrance to said selective catalytic reduction system.

27. The selective catalytic reduction system of claim **19** wherein said manifold pipes are in fluid communication with said selective catalytic reduction system via circumferentially spaced ports.

28. The selective catalytic reduction system of claim **19** wherein said manifold pipes are positioned substantially parallel with respect to the flow of said waste stream.

29. The selective catalytic reduction system of claim **19** wherein said manifold pipes are positioned at an angle with respect to the flow of said waste stream.

30. The selective catalytic reduction system of claim **19** wherein said chamber of said air bustle is in fluid communication with said selective catalytic reduction system via circumferentially spaced ports.

31. The selective catalytic reduction system of claim **19** further comprising a plurality of ammonia injection grid assemblies and a plurality of selective catalytic reduction catalyst assemblies, ordered such that each ammonia injection grid assembly is immediately followed by a selective catalytic reduction catalyst assembly.

32. The selective catalytic reduction system of claim **19** further comprising a distribution grid located intermediate of said gas input duct and said ammonia injection grid assembly and said selective catalytic reduction catalyst assembly.

33. The selective catalytic reduction system of claim **19** further comprising at least one air intake duct located intermediate of said gas input duct and said ammonia injection grid assembly and said selective catalytic reduction catalyst assembly.

34. The selective catalytic reduction system of claim **33** further comprising at least one air intake duct located upstream from said distribution grid.

35. The selective catalytic reduction system of claim **19** further comprising a plurality of catalyst beds, ordered such that each catalyst bed is immediately followed by an ammonia injection grid assembly.

36. A combined flow mixing, tempering and noise suppressing apparatus for a selective catalytic reduction system, wherein said selective catalytic reduction system comprises a gas input duct, a catalyst bed located downstream from said gas input duct, an ammonia injection grid assembly and a selective catalytic reduction catalyst assembly located downstream from said catalyst bed, and an exhaust stack located downstream from said ammonia injection grid assembly and said selective catalytic reduction catalyst assembly, said combined flow mixing, tempering and noise suppressing apparatus comprising:

a lobe mixer positioned downstream from said gas input duct and upstream from said catalyst bed in said selective catalytic reduction system, and said lobe mixer comprises lobe depressions that extend toward a centerline axis of said gas input duct and alternating lobe protrusions leading away from said centerline axis wherein said combined flow mixing, tempering and noise suppressing apparatus further comprises a toroidal air manifold having a plurality of air manifold pipes or a hollow annular air bustle forming a chamber to which a secondary stream under pressure is supplied.

37. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said lobe mixer is constructed from a casting of metal, a formed or pressed sheet metal or welded sections of plate.

38. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said lobe mixer is coated with a refractory material.

39. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said lobe mixer comprises six lobe depressions and six lobe protrusions in a sinusoidal profile.

40. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said manifold pipes are in fluid communication with said selective catalytic reduction system.

41. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said manifold pipes are positioned substantially parallel with respect to the flow of said waste stream.

42. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said manifold pipes are positioned at an angle with respect to the flow of said waste stream.

43. The combined flow mixing, tempering and noise suppressing apparatus of claim **36** wherein said chamber of said air bustle is in fluid communication with said selective catalytic reduction system.

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